ENVIRONMENTAL QUARTERLY

Vibration Testing — The Fundamentals

♦

Air Force Studies Sand and Dust Testing for Realistic Specifications

♦

FTC Confers with Environmental Equipment Industry on Trade Practice Rules

♦

IEE Membership Drive — New Engineering Society Explained

Official publication of the
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Questions and Answers

We invite you to send us questions suitable for publication in this department, and to send us solutions to problems posed by other peoples' questions.

Here is last month's question and its answer:

The Question

Dear Sir:

AVCO's Advanced Development Division is in the process of procuring several high altitude test chambers for our laboratory. Because of the extreme low pressures to which equipment is subjected, it seems likely there would be danger from high-energy particles in the event of implosion.

The equipment manufacturers do not appear to be disturbed by this prospect; however, from the standpoint of safety, we are interested in determining if accidents of this type have occurred among users of high altitude chambers.

CHARLES COHEN
Associate Engineer
AVCO Manufacturing Corporation

The Answer

Dear Sir:

The Pyrotechnics Laboratory at this Arsenal has recently completed the construction and installation of an 8,000-cubic-foot high-altitude chamber, provided with four viewing ports. This chamber is 75 feet long and is built in the shape of a truncated cone having a maximum diameter at its base of 15 feet and tapering to 4 feet. Although we have had no implosions at simulated altitudes over 100,000 feet (and hope we never do), we thought Mr. Cohen might be interested in the precautions we are taking to prevent this occurrence.

Since the Laboratory is engaged in the development of small cartridges and other pyrotechnic items for use at high altitudes, this test chamber has received almost continuous use on a six-day-a-week basis for the testing and evaluation of various explosive and burning type items. To prevent the chipping or cracking of the sight glasses, two sheets of lucite have been placed in front of the viewing ports to reduce the velocity of, or stop, high speed fragments from impinging on the glass viewing port. In addition, plans are now being made to install an additional glass port mounted on an "O" ring assembly directly over the existing port. In this way, we hoped to overcome any implosion that might occur if a high velocity fragment penetrates the lucite shields and breaks the sight glass. At one time, one of the sight glasses did crack during the evacuation of the chamber; however, we were able to bring the tank down to ambient pressure from 60,000 feet before any implosion occurred.

STANLEY RESNICH, Chief
Pyrotechnics Radiation Research Sect.
Picatinny Arsenal (Ordnance Corps)

(Continued on Page 24)

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Vol. 2, No. 4 Fourth Quarter 1956

ENVIRONMENTAL QUARTERLY

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The *Environmental Quarterly* is circulated to men concerned with environmental simulation and testing in industry and in government agencies. It is the only magazine devoted exclusively to environmental science, simulation, and testing.

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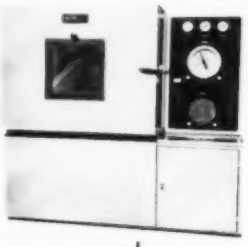

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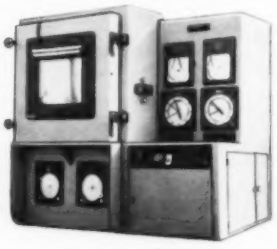

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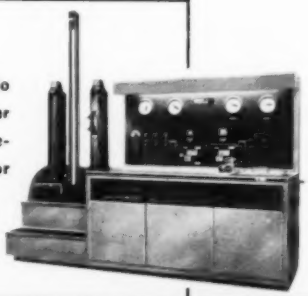

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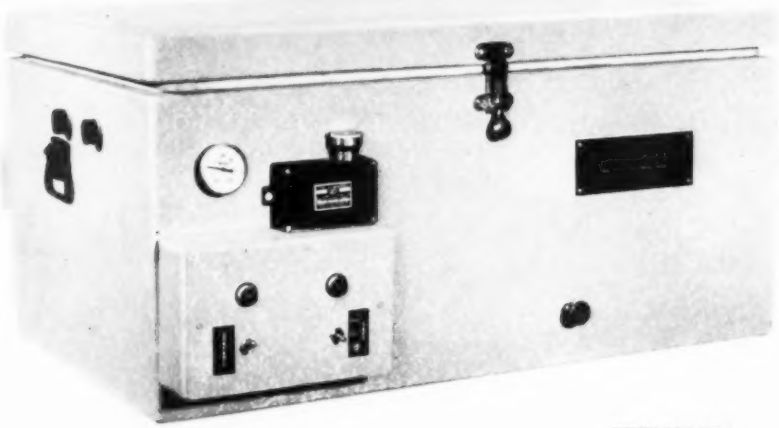

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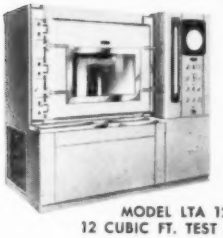

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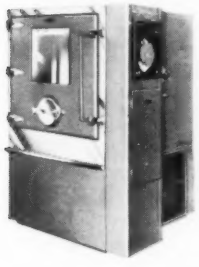

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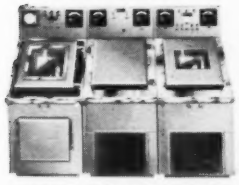

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VIBRATION TESTING FOR THE NEOPHYTE

ROBERT L. STALLARD, General Electric Company
Light Military Electronic Equipment Department

"This article is dedicated to those manufacturers and their engineers who regard vibration testing as a 'new-fangled' way of complicating design problems . . . My intention here is to offer a practical guide to neophytes in the 'shake-and-shimmy' business, enabling them to perform actual, realistic tests within specification."

In recent years the military electronics industry has seen the requirements for vibration testing grow from nothing at all to a sophisticated body of techniques that makes use of such enigmatic terms as "spectral density" and may employ frequencies up to or even above 2,000 cycles per second.

The merits of sine-wave and random-wave vibration testing have been discussed in many technical meetings. Many opinions have been expressed, but only a small amount of quantitative data has been presented. The designer's question of what causes structural damage – the high peaks encountered in random vibration, or the rms g (root mean squared gravity) level of the vibration – remains unanswered. It is not my purpose to enter into a detailed argument on this question, but merely to point out the absence of conclusive information.

Since a test specification usually accompanies the contract under which equipment is built for the government, the general principles of vibration testing may appear to be of little concern to the industry. However, regardless of what the test specification *says* (or fails to say), in essence it always means: *Test the product so that, after it has passed the test, there is reasonable certainty it will survive in its destined environment.*

Knowingly to test a product according to an unrealistic specification is poor engineering – and a waste of time and money. Everyone engaged in environmental testing is responsible for knowing how realistic the test specification is. If research convinces him that the test is too severe or not severe enough, he should ask the contracting agency for a change in specification. An over-designed product – one built to satisfy demands that the customer has not made – is likely to be unduly expensive; while an under-designed product is likely to be unreliable or downright worthless. The purpose of environmental testing is to fit a particular product to a specific job.

Before joining GE, Mr. Stallard worked for five years in the Applied Physics Laboratory at Johns Hopkins University, on vibration analysis, environmental tests, missile power supplies, and battery research. He has an ME degree, 1944, from Stevens Institute of Technology.

Vibration Specifications

Existing military test specifications fall into two general categories. One type calls for sine-wave testing at a specified sweep rate (such as a change in frequency at constant amplitude up to some frequency where acceleration reaches a specified value – usually 10 g) and then at constant acceleration up to 500 or 2,000 cps. In addition, this type of specification calls for sine-wave endurance testing at resonant frequencies at specified levels for unspecified lengths of time. Another specification – primarily for testing missile components – calls for a specified frequency bandwidth, with sine-wave excitations at different frequencies superimposed on the random forcing function.

For both types of tests, the frequency requirements far exceed the performance of mechanical testers. Hence the electrodynamic type of device is necessary. The latter is basically an overgrown dynamic loudspeaker in which a specimen mounting table instead of a cone is connected to the voice coil. Figure 1 shows examples of two such shakers that are available commercially.

To drive the shaker, two different kinds of power supplies are generally used: principally a group of alternators or an electronic amplifier.

For sine-wave testing, the shaker may be driven either by alternators or by an amplifier that obtains its signal from a sine-wave oscillator. For random-noise vibration testing, the choice of power supply to drive the shaker is limited to the electronic amplifier.

Selection of the Shaker

Commercial vibration equipment is rated as to peak force in pounds, based upon sine-wave excitation. This force rating is determined from the maximum allowable power that can be dissipated in the shaker. A more realistic rating would probably be based on the maximum allowable rms force – which is what manufacturers now call the rated force multiplied by 0.707. This rms level corresponds to the maximum allowable operation of the shaker under conditions of random noise vibration, sinusoidal vibration, and a mixture of both. Shakers are available in various rated forces from 25 to 15,000 pounds and above. Choice of the shaker for a given application depends on the weight of the heaviest specimen to be vibrated at the maximum required acceleration.

For example: to perform a sine-wave vibration test on a 100-pound package at 15 g's peak, calculation of the needed shaker size would be as shown in Equation A. The weight of 100 pounds for the voice coil was chosen because machines of this force rating generally have a voice coil weight of about 100 pounds.

$$\begin{aligned}\text{Rated Force} &= \text{g (peak) x [Voice Coil Weight + Specimen Weight]} \\ &= 15 \times [100 + 100] \\ &= 3{,}000 \text{ pounds}\end{aligned}$$

EQUATION A

For a corresponding random-noise vibration test in which the required level of vibration is 15 rms g for a 100-pound specimen, the required force rating of the shaker would be as shown in Equation B.

$$\begin{aligned}\text{Rated Force} &= \text{Rms g x } \sqrt{2} \text{ x [Voice Coil Weight + Specimen Weight]} \\ &= 15 \times \sqrt{2} \times [100 + 100] \\ &= 4{,}250 \text{ pounds}\end{aligned}$$

EQUATION B

These calculations show that a shaker rated at 5,000 pounds with a 100-pound voice coil is capable of vibrating a 100-pound specimen with sine-wave excitation at 15 g peak or with random-noise at 15 rms g.

For a test of mixed sine-wave and random-noise, the force required may be found as in Equation C.

$$\text{Rated Force} = \left\{ \begin{array}{l} [\text{Rms Random g}]^2 + [\text{Rms Sine @ } f_1]^2 \\ + [\text{Rms Sine @ } f_2]^2 \ldots [\text{Rms Sine @ } f_n]^2 \end{array} \right\}^{1/2} [\text{Voice Coil Weight} + \text{Specimen Weight}]$$

EQUATION C

For random type excitation, the vibration machine must be capable of sustaining both forces and displacements in excess of its rating for short periods of time. The value of 4.5 is accepted as a representative overload factor for random acceleration tests. Therefore, the 5,000-pound shaker would be required to produce a peak force of 22,500 pounds (4.5 x 5,000).

Another major consideration in choosing a shaker is the first axial resonant frequency of the voice coil assembly, since this governs the shaker's cutoff frequency. Most of the large equipments now available – shakers having ratings of 5,000 pounds or more – have an upper cutoff frequency slightly above 2,000 cps. This means that they cannot be used effectively to conduct vibration tests above 2,000 cps. There are, however, smaller shak-

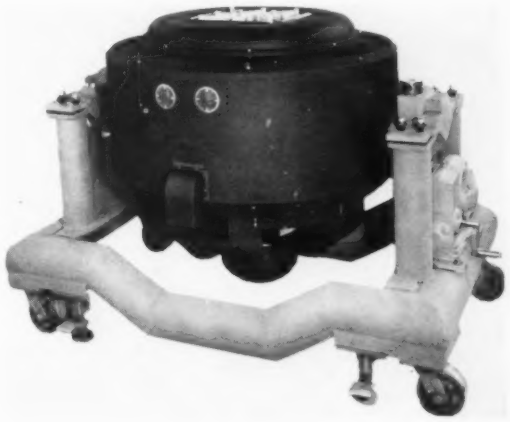
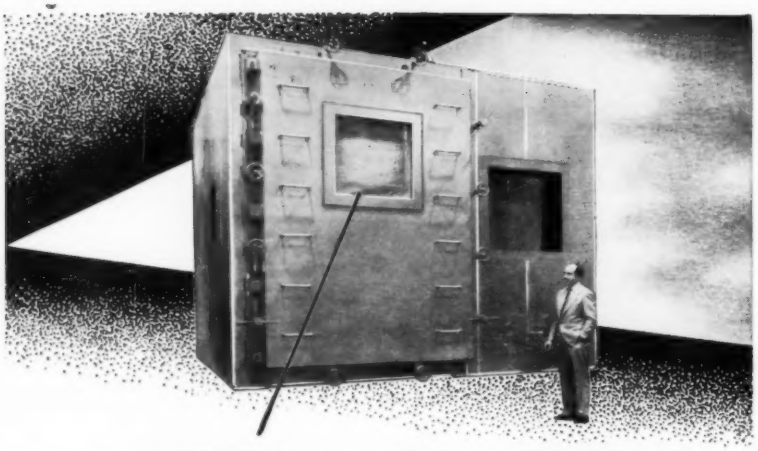


Figure 1. Examples of commercially available shakers of 5,000-pound force output.



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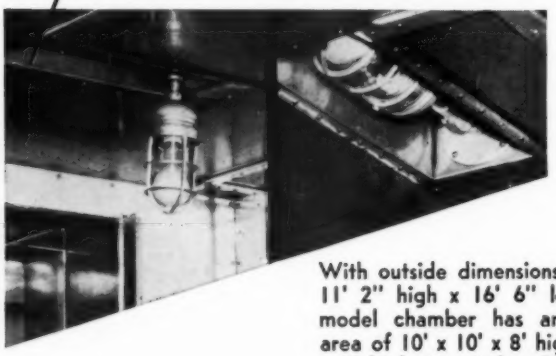

With outside dimensions of 13' 2" wide x 11' 2" high x 16' 6" long, this standard model chamber has an interior working area of 10' x 10' x 8' high. Door is 5' wide x 8' high, its window 30" x 30", and wall window 36" x 36".

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Amplifier or Alternator?

As soon as a manufacturer gets a production contract that specifies random-noise vibration testing, he is committed to buying an electronic amplifier with a random-noise control console to drive his shaker. However, if the contract requires sine-wave testing only, then it is difficult to decide which type of drive unit to use. On the basis of cost alone, the alternators win out. The difficulty is that the inherent characteristics of an alternator power supply will limit future testing to single-frequency sine-wave techniques. With an amplifier, any necessary sine-wave testing could be done satisfactorily with a sine-wave oscillator as source of driving signal.

A random-noise vibration system, complete with amplifier, control console, and shaker is a very useful tool. Much research work must be done on defining the relationship between random noise vibration, sine wave vibration, and damage before the decision can be made on whether or not to abolish sine wave testing in favor of random wave testing. At present, vibration test specifications requiring random noise tests are the exception rather than the rule.

Possibly, as aircraft speeds increase, and greater emphasis is placed on guided missile production, requirements for random noise testing will be increased. In addition, the intense acoustic noise generated by jet and rocket engines and boundary layer turbulence at high speeds are sources of vibration that are being recognized as extremely damaging. This type of noise has been shown to be random in nature.

Although at present there is no known method of specifying a mechanical vibration test simulating acoustically-induced vibration, in my opinion it is possible to contrive a test of equal damage potential.

Selection of the type of unit for driving a shaker should be influenced by the flexibility afforded by the amplifier system. Although purchase of a random noise control console in addition to the amplifier may now seem unjustified for most manufacturers, future conditions may demand a complete random-noise testing system.

Specific Considerations

Once you have decided what type of unit best suits your needs, consideration should be given to placement of the equipment as well as to related problems.

First thought must be given to power supply. Vibration test experiment has high power requirements. For example: a 5,000-pound shaker requires a 25-kilowatt amplifier that draws 60 KVA from a 480-volt, 3-phase power line, and a 15,000-pound shaker requires a 70-kilowatt amplifier drawing 150 KVA. Power requirements are about 30 percent less for alternators. In either case, this amount of power is not readily available in the average small plant.

Assuming that you have chosen an amplifier, remember the enormous excessive heat generated that must be dissipated. Since amplifiers are usually only 50 percent efficient, they are equipped with internal cooling fans that circulate air to exhaust the heat generated in the unit.

Owing to the high power levels, the excess heat should be dissipated outside the building housing the unit. If this is not provided for, personnel within the area will be subjected to exhaustive heat levels. The heat dissipated by a 75-kilowatt amplifier would heat three 3-bedroom houses in the coldest weather. Ducting should be provided to exhaust the heat externally. If the test area is air-conditioned, housing the amplifier in a room apart from the test area would decrease the load of the required air-conditioning unit by a large factor.

For some amplifiers water cooling of power tubes will be required.

Mounting the Shaker

Mounting of the shaker is another important factor. There are two known methods of doing this. One is to set the shaker on isolators and the other is to bolt the shaker to a large mass such as a concrete slab 8 to 10 times heavier than the shaker.

Mounting on isolators provides a more flexible test stand capable of being moved to various positions and places with ease. When a large amount of test work is involved, this method of mounting is most satisfactory.

Mounting the shaker on solid concrete offers the advantage of increasing the effective shaker mass. Therefore, at high g's, with heavy specimens, the shaker will not dissipate any appreciable energy in shaking itself.

For experimental engineering tests, one thing frequently overlooked in the setting up of a vibration test facility is adequate space allowance around the shaker for auxiliary equipment. For example, electronic engineers require an amazing number of relay racks of equipment just to operate a small package under test.

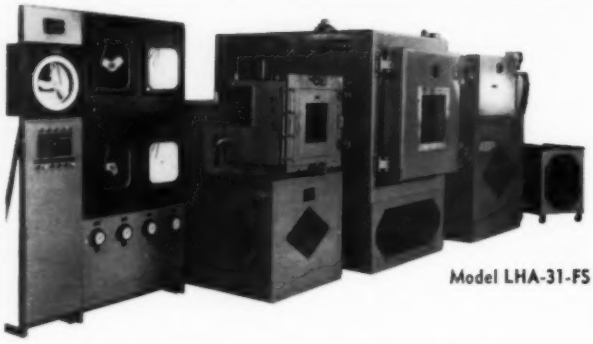
Further space must be provided for the shaker control panel, and the shaker operator must have an unimpeded view of the equipment at all times. A recommended minimum free area around a 5-foot diameter shaker would be one 15 by 15 feet. An area less than this could seriously hamper testing operations.

To Shake or Not to Shake

These various factors would seem to warrant a separate housing unit for the vibration test facility, away from shop and office areas. However, two other factors must be considered in arriving at the decision "to shake or not to shake." These also strongly support the idea of housing the vibration test facility separately, and even of housing each part of the unit in a separate room.

The first of these two factors is the high level of acoustic noise generated by the shaker. This noise level reaches a pitch that makes it virtually impossible for anyone not concentrating on the test itself to think. If building a separate housing unit is not feasible, a sound-proof enclosure should be provided.

(Continued on Page 16)



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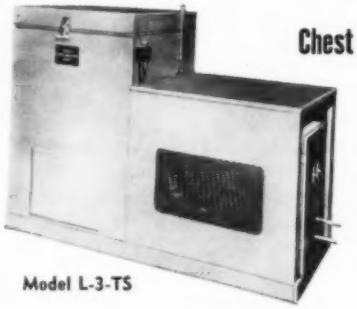

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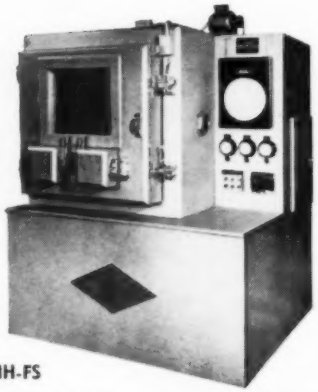

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AIR FORCE INVESTIGATES SAND AND DUST TESTING

WAYNE B. YARCHO, Environmental Criteria Branch, Wright Air Development Center

A study to develop a more realistic sand and dust testing procedure has been completed for WADC by Southwest Research Institute, San Antonio, Texas.

The test procedure in most general use by the Air Force has been Procedure I, Specification MIL-E-5272. Equipmene items are evaluated for resistance to damage from sand and dust by exposure in a test facility under these conditions:

1. Duration of test – 12 hours.
2. Temperature – 6 hours at 77°F, 6 hours at 160°F.
3. Air velocity – 200 ± 100 feet per minute.
4. Relative humidity – 30 percent or less.
5. Dust concentration – 0.1 to 0.5 grams per cubic foot.
6. Type of dust – 140 mesh silica flour.

The test is run in two stages, six hours each at the low and high temperatures with the equipment not operating. After the test the equipment is cooled to room temperature and inspected and operated to determine the effects of the exposure.

Procedure II, MIL-E-5272, a less-used sand and dust test, is similar to Procedure I, except that the total test time is eight hours in one stage, and the test temperature is 77°F.

Both Procedures have been challenged from the standpoint of realism. Since an extremely heavy layer of dust is deposited on the test item, some suggested that small cracks or apertures in equipment cases may quickly become plugged, preventing the amount of dust infiltration that might result under natural conditions. A test suitable for equipment in operation has also been requested by some testing activities.

Under the terms of the contract, the contractor commenced the research study by conducting an extensive survey of existing literature. The important characteristics of the dust environment to be encountered in service were classified according to effect, dust environment components, and factors influencing conditions.

In general, airborne dust was found to affect equipment adversely in two respects: by abrasive wear and by clogging or plugging. Investigation of abrasion was classified into erosion studies, as applied to bearings, linkage joints, finishes, etc., and air cleaner or filtration tests in conection with the study of internal engine or assembly wear. The category of dust abrasion, although important, was found to be limited to certain specialized types of equipment, and thus not applicable to the entire field of Air Force items. Directly interested Government and commercial activities were found to be continually investigating this aspect of the dust problem. Detailed study of abrasion was not undertaken.

The degree of clogging or plugging of equipment was found to be directly related to the amount of dust penetration into the case or protective cover. The second phase of the research study was thus devoted to the development of a penetration type sand and dust test.

Dust conditions encountered in service were found to be due both to operation of equipment and to natural wind, in localities of dry, unsurfaced terrain. Data was compiled on dust concentrations resulting from varying combinations of natural and induced conditions. Information was obtained on dust composition and particle size. Dust environments resulting from equipment operations were found to be of the most importance since the intensity equaled or exceeded that of the most severe natural dust storms, and frequency of occurrence was of course much greater.

Based on the data obtained, a series of dust penetration tests was conducted on specialized test items, in a test facility designed and constructed by the contractor. The test items employed for the developmental phase of the study consisted of three small metal boxes, each penetrated by a slot to permit the infiltration of dust. Slot widths were 0.003, 0.005 and 0.009 inches, to simulate the range of widths in case or cover joints of Air Force equipment. Each parameter was varied in turn while all other variables were held constant:

Duration of test period – 10 to 240 minutes.
Relative humidity – 10 to 65% at 80°F.
Air velocity – 220 to 5,300 feet per minute.
Temperature – 15 to 160°F.
Dust concentration – 0.01 to 0.5 grams per cubic foot.
Type of dust – 140 mesh silica flour; AC Spark Plug Dust, fine; AC Spark Plug Dust, coarse.

Dust penetration was found by measuring the weight increase of the test specimens after each test. Weight gain was then plotted against the parameter value for each variable. The most suitable value for the variable was selected as that for which the slope of the resulting curve indicated a marked change, that is, where the rate of weight gain commenced to decrease sharply. Decrease in weight gain in all instances was due to plugging of the crack in the test item by dust particles, thus decreasing dust penetration to the interior.

These optimum conditions for a tentative dust test procedure were established:

Duration – 60 minutes.
Relative humidity – 30 percent or less.
Air velocity – 1300 ± 100 feet per minute.
Temperature – 80°F.
Dust concentration – 0.1 to 0.25 grams per cubic foot.

(Continued)

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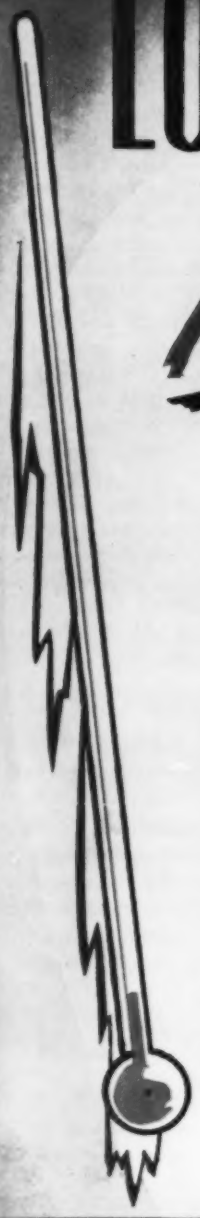

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SAND AND DUST TESTING

(Continued)

Type of dust – 140 mesh silica flour, MIL-E-5272.

These detailed levels, although not corresponding in all instances to maximum total dust infiltration, were considered, when integrated, to be capable of producing the maximum dust penetration consistent with realism and economy of testing technique.

The final phase in the test study consisted of a trial of the tentative proposed test procedure in comparison with Procedure I of MIL-E-5272. Actual items from Air Force stock – electrical relays, switches and a mechanical actuator – were used as test items, in both the operating and non-operating condition.

In general there was slight difference between the two test procedures in regard to adverse effects of sand and dust on equipment. The mechanical item was found to fail more consistently when tested in the non-operating or intermittent operating conditions than during continuous operation for either test. Without the cover in place, the MIL-E-5272 test was more severe, because of the greater volume of dust moved. When the equipment was operated with the cover attached, failure usually took place within the first hour of test.

The electrical equipment failed more consistently under conditions of continuous operation. For items with minute case openings, the tentative test was more severe. No significant difference could be established between the severity of the two test procedures, but malfunctions resulting from either took place after about one hour of operation.

As a result of the comparative tests, the tentative dust test procedure previously described was modified as follows:

Duration – 180 minutes
Equipment Operation – 1. Mechanical – Non-operating. 2. Electrical – Operating

Additional work on all phases of the dust problem will be necessary prior to incorporation of the tentative procedure in test specifications. Although the test procedure selected was based on data considered strongly indicative of relationships which result in dust penetration, substantiating tests will be conducted on a wider selection of equipment items. **END**

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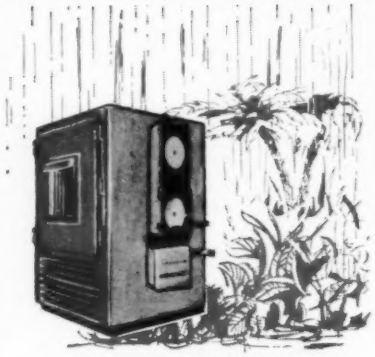

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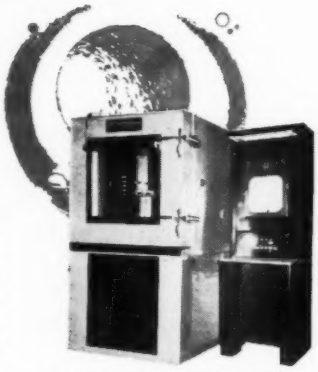

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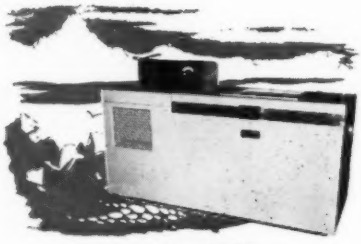

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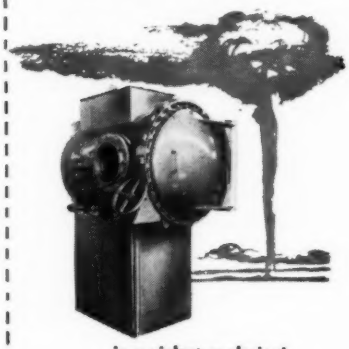

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In the last issue of the *Environmental Quarterly*, we reported the creation of the Institute of Environmental Engineers. The IEE has now completed its legal structure, including its by-laws, and with this issue of the Quarterly the IEE formally launches its membership campaign.

* * * * *

The science of environmental simulation and testing is a young and growing field having problems and techniques distinct from areas on which it borders, such as mechanical and refrigeration engineering, instrumentation, industrial research, etc. Environmental simulation and testing, or, in other words, *environmental engineering*, stands by itself.

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The IEE is the direct descendent of the Science Section of the Environmental Equipment Institute. Because of rapid growth and enthusiastic interest, the Science Section became the IEE, Incorporated, in mid-summer 1956.

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(Continued on Page 24)

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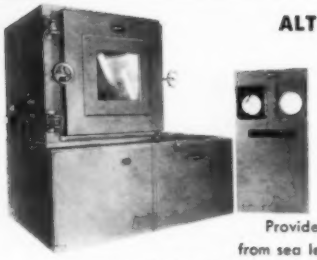

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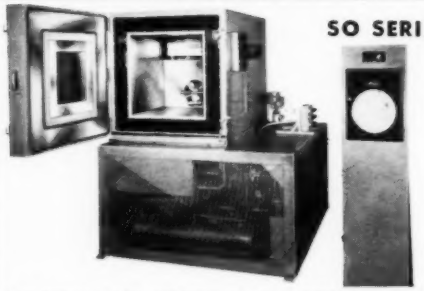

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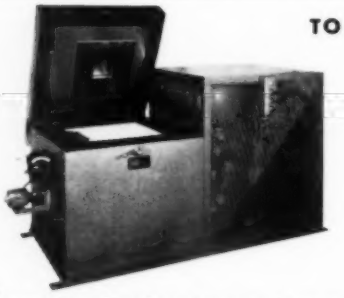

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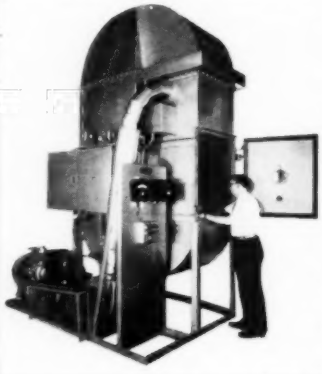

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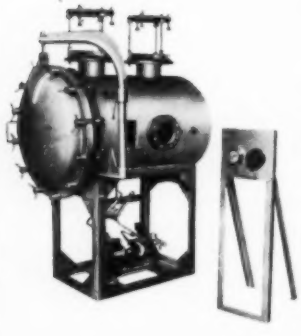

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ROBERT L. STALLARD, Light Mil. Elect. Equip. Dep., General Electric Co., French Road, Utica
WILLIAM A. STEAD, JR., Servomechanisms, Inc., Post & Stewart Ave., Westbury
ALAN E. SUROSKY, Nuclear Development Corp. of America, 114 Soundview Ave., White Plains
JOHN M. THOMPSON, 405 Elm St., Rome
ALEERT TRAMPOSCH, 52 Sunrise St., Plainview
J. C. WARD, Env. Test. Sect., General Precision Lab., Inc., 63 Bedford Road, Pleasantville
SAMUEL E. WEAVER, JR., Airborne Instruments Lab., 160 Old Country Rd., Mineola

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HENRY L. STEIN, American Electronics Labs., Inc., 641 Arch Street, Philadelphia 6
SAMUEL H. SUGARMAN, Bulova Res. & Dev. Labs. Inc., c/o Hunter Mfg. Corp., Bristol

(Continued on Page 25)

VIBRATION TESTING FOR THE NEOPHYTE

(Continued from Page 7)

The second factor, equally disturbing, is that of vibration, which will occur regardless of the type of shaker mounting and will be transmitted throughout a rather large area. If at all possible, the floor of the vibration test area should be isolated from the surrounding floor area.

Mounting the Specimen

The specimen can be mounted directly on the table, or it can be suspended by guy wires from the ceiling and connected to the shaker table with a suitable push rod. (A variation of the cable-support system is the use of an auxiliary table mounted on flex plates.) Direct mounting is the more desirable method. The limit of the weight that may be so mounted is governed by the allowable deflection of the table. The maximum displacement during the test should be limited so that the over-travel switches are cleared by at least 1/32 of an inch.

When the specimen is mounted directly, extreme care must be taken to locate the cg (center of gravity) of the specimen plus its mounting fixture coincident with the thrust axis of the shaker. Otherwise, sidewise accelerations that might damage the shaker may be generated. Since the dynamic cg will shift with change in frequency due to specimen resonances, it is impossible to align the cg directly with the thrust axis for all frequencies. However, in most cases, the use of the static cg as reference point will be satisfactory. Conceivably, for a few designs, the use of static cg as a reference point could still allow damaging sidewise motion. For this reason, it is advisable to monitor the sidewise acceleration and limit it to less than 1/5th the axial acceleration.

Mounting bracket design is, naturally, of vital importance. The bracket should be designed to approximate the mounting configuration that will be used in the end environment. An improperly designed bracket can produce erroneous test results.

When the weight of the specimen is greater than the maximum weight that may be mounted directly on a shaker table, it should be either suspended by guy wires or mounted on a separate flex-plate supported table. As for direct mounting, the cg of the specimen and mounting bracket must be coincident with the thrust axis of the shaker (Fig. 2).

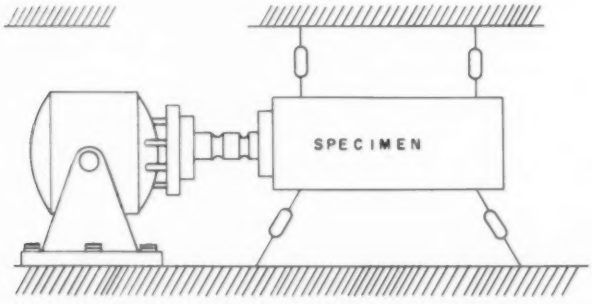
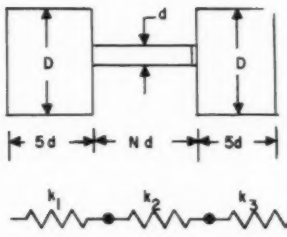


Figure 2. System of mounting specimen off the table.



TOTAL SPRING CONSTANT K

$$\frac{1}{K} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3}$$

LET $D/d = B$

$$\frac{1}{k_3} = \frac{1}{k_1} = \frac{\ell}{AE} = \frac{5d}{B^2 d^2 \frac{\pi}{4} E} = \frac{20}{B^2 d \pi E} \text{ IN/\#}$$

$$\frac{1}{k_2} = \frac{\ell}{AE} = \frac{Nd}{d^2 \frac{\pi}{4} E} = \frac{N}{d \pi E} \text{ IN/\#}$$

WHERE E = YOUNGS MODULUS = 30×10^6 PSI

Figure 3. Schematic diagram of a push-rod and formulas for calculating the spring constant.

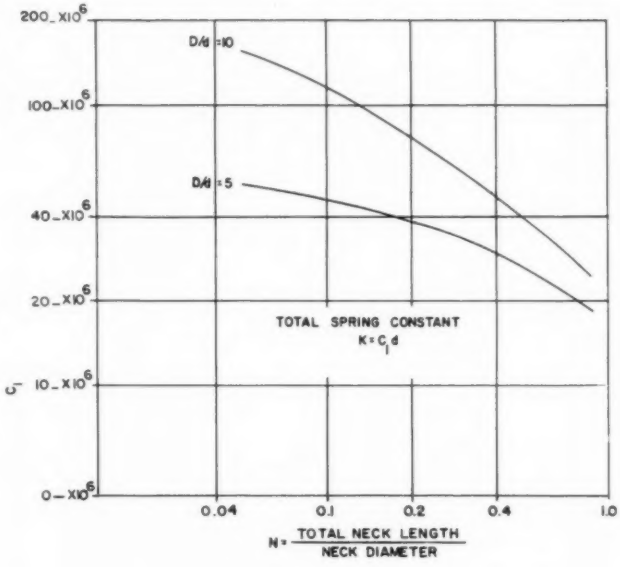


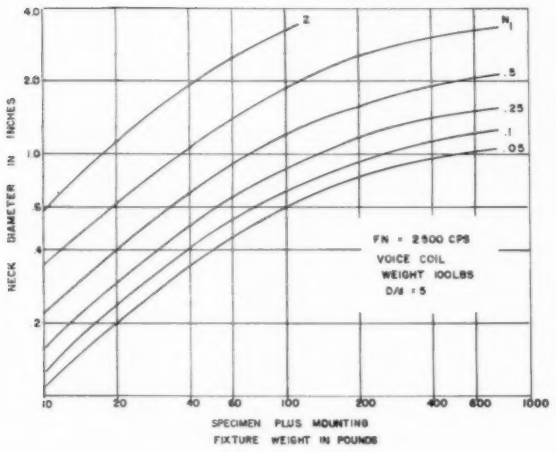
Figure 4. Curve of C_1 versus N for determining the total spring constant of the push-rod.

Push-rod Design

For this arrangement, the push-rod design is the most important factor. The push-rod connects the shaker to the load and acts as a mechanical fuze that allows motion

$$\omega_N = \sqrt{\frac{K}{M_1}\left(1 + \frac{M_1}{M_2}\right)}$$

Figure 5. Schematic diagram of a spring mass system when specimen is mounted off the table.



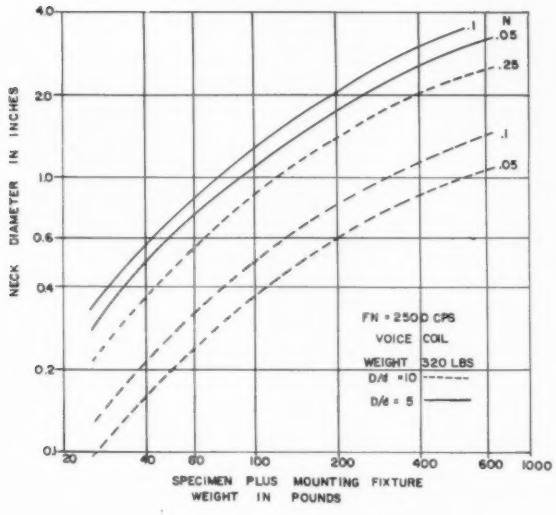


Figure 6. Curves for determining push-rod diameter for various speciment weights to maintain a resonant frequency of 2,500 cps.

of the specimen normal to the thrust axis of the shaker without imparting serious torsional moments to the voice-coil assembly. The push-rod acts as a spring with the mass of the voice coil at one end and the mass of the specimen at the other. The resonant frequency of this mass-spring combination should be placed above the maximum frequency at which any test is to be run.

An idealized push-rod is represented in Figure 3, and the relationship between the total spring constant K and the geometry of this idealized push-rod is shown in the equation. From this equation the curves in Figure 4 were computed. These curves show the relationship between the total spring constant K, and the neck diameter, d, of the push-rod.

The spring mass diagram for the system is shown in Figure 5, and the resonant frequency for this system is represented by the equation.

Since most testing done today requires that the specimen be vibrated at frequencies up to 2,000 cps, a resonant frequency of 2,500 cps was chosen for designing an illustrative push-rod. Figure 6 was computed from the equation on Figure 5, illustrating the effect of specimen mass upon the push-rod size required to maintain a resonant frequency of 2,500 cps in conjunction with machines having voice-coil weights of 100 pounds and 320 pounds.

(Continued)

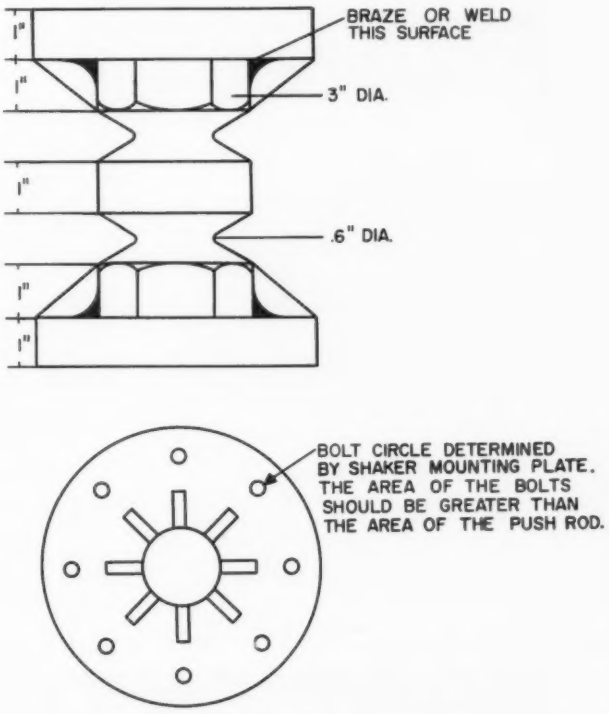
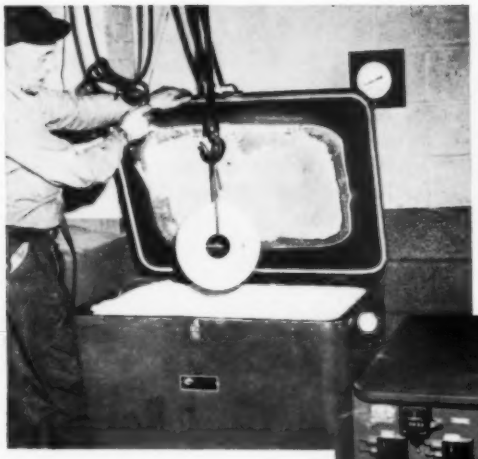
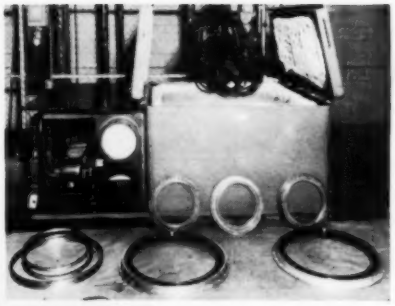


Figure 7. Example of a push-rod for a 100-pound specimen.





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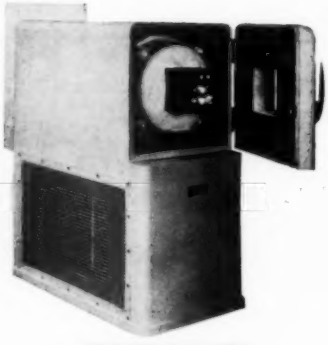

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Examination of Curves

Examination of the curves shows that the push-rod size must be extremely large for vibration of a specimen of nominal size up to 2,000 cps. For example, to test a 100-pound specimen with a shaker having a 100-pound voice coil, based upon a D/d ratio of five, and a neck length of 0.05d, the minimum dimensions of a satisfactory push rod would be three inches for the major diameter and 0.6 inches for the neck diameter in order to obtain a 2,500 cps resonant system.

Figure 7 represents an actual push-rod designed from this theoretical data. In the actual rod, two neck waves substituted for the original single neck, and the angle of the slot were changed from a saw-cut type to a V type with a slope of 60-degrees. (Changing this angle will influence the total spring constant only slightly since very little stress would have been developed in the section that was removed.) Face plates were added to facilitate bolting the specimen to the shaker head and specimen mounting jig.

Examination of the push-rod drawing shows that the desired frequency of 2,500 cps will probably not be obtained. The mounting-bolt area will decrease the total spring constant considerably since their total area will be less than the area of the 3-inch diameter body of the rod. Also, converting the theoretical system with a saw-cut slot to an equivalent V slot as shown cannot be easily solved for theoretically, and there is no guarantee that the "guessed" configuration will yield the desired results.

In addition, a neck diameter of 0.6 inches with a diameter-to-neck ratio of 0.05 inches will, in general, defeat one of the original purposes of the push rod, which is for the rod to act as a mechanical fuze and to offer very little restraint in a direction normal to the thrust axis of the shaker.

For these reasons, the use of a push rod is *not* recommended. Whenever possible, the specimen should be mounted directly on the table.

Accelerometers

An accelerometer is used to monitor the vibration input to the specimen. The accelerometer should be mounted as near as possible to the points where the specimen is mounted on the bracket. If there are several mounting points, mounting an accelerometer at each mounting point is desirable. When this is done, the accelerometer indicating the maximum acceleration should be used to monitor the test. During a sine-wave test, the frequency is varied – the maximum acceleration shifts from accelerometer to accelerometer because of the variegated resonances found in a complex specimen.

The type of accelerometer usually found most advantageous is of the self-generating barium titanate piezoelectric crystal variety, available in various sizes and shapes from several manufacturers. A type of accelerometer should be chosen that can be easily attached to the specimen mounting flanges and that has suitable frequency-response characteristics. Since most of the accelerometers have resonant frequencies above 10 kc, the frequency response characteristics are seldom a problem in vibration tests.

The accelerometer should be carefully mounted because in many types the case itself is an integral part of the spring-mass system, and any distortion of the case due to bolting or clamping it to the specimen can change the calibration. One method that has been devised is the use of double-sided tape instead of screws to fasten the accelerometer to the specimen. In cases where drilling a hole could ruin the specimen, this scheme may be the only practical solution. However, the effect of the tape upon the system arising from its flexibility is not well documented, and thus the procedure should be used only with great care.

Cathode Followers

Barium Titanate Accelerometers require that cathode followers be used across their output terminal so that the resistive load is as high as possible. This is necessary since an accelerometer acts essentially as a capacitance generator. Therefore, the higher the resistance of the load, the lower the frequency at which the units may be used without any decrease in their output. With a proper cathode follower, most units may be operated efficiently at frequencies as low as 10 cps.

Cable Noise

One of the biggest booby-traps in vibration work is cable noise. With the extremely high operating impedance of the accelerometer-cathode follower combination, noise is easily generated. The presence of noise can waste considerable test time, since the indicating meter is unable to differentiate between noise and the signal. If noise is present, the test will not be run at the proper level and the test result will be invalid.

Most of this noise is generated in the cable by motion of the shielding with respect to the inner conductor. A great deal of research has been done on this problem, so that today anti-noise cables and connectors are available that operate well under rather adverse conditions. However, cables and connectors become worn with extended use and lose their original properties. After installation of the accelerometers and cathode followers, the acceptability of the system can easily be checked by the simple expedient of wiggling the cable by hand. If an excessive reading is obtained on the monitoring meter, the source of the noise should be eliminated.

Monitoring Meters

The output of the cathode follower may be fed directly to a vacuum tube volt-meter if a sinusoidal test is contemplated. If a random noise test is contemplated, an rms meter must be used. The rms VTVM may be connected directly to the output of the cathode follower. However, if a thermocouple-type meter is to be used as an actual rms indicator, its input impedance is usually too low to be connected directly to the cathode follower output and, therefore, an isolation amplifier must be in-

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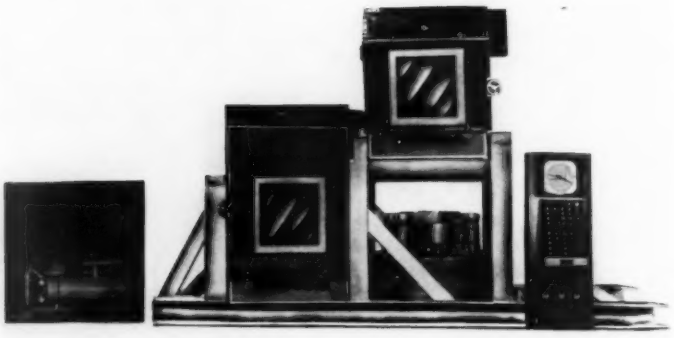

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Vibrator operates from outside the chambers and can be used for horizontal vibration in the lower chamber and vertical vibration in the upper chamber. The vibrator is positioned up or down by a hydraulic lift.

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serted between the cathode follower output and the meter input. Many manufacturers include isolation amplifiers as an integral part of the cathode follower assembly.

Sine-Wave Testing

For sine-wave testing of the sweep variety, automatic cyclers are available from the shaker manufacturers, and are designed to operate in conjunction with the amplifier-oscillator method of driving the shaker. With a few simple settings, these devices permit a test to be made at a preselected rate of change of frequency. As the signal frequency is increased, the specimen is excited at constant amplitude until a specified g level is reached, at which point the g level is maintained until the upper frequency limit of the specification (500 cps or 2,000 cps) is reached. After this, the frequency is decreased at the same rate, and the applied acceleration to the specimen is maintained in the same manner as during the frequency increase cycle. As many cycles as desired may be made without resetting the device.

The automatic servo incorporated in the automatic cycling device limits the acceleration of the specimen by monitoring any accelerometer mounted on the specimen. The mounting position on the specimen of these accelerometers must be determined by individual case needs.

A prudent step for the operator is to mount an additional accelerometer "piggy-back" to the monitor and consult it as a visual meter to maintain a constant check on the servo operation.

When such an automatic device is unavailable and the tests must be run by manual control, care should be taken not to overdrive the specimen at the resonant frequencies. With solid metal structures in which the Q (amplification at resonance) is in the range of 30 to 50, it is very easy for the acceleration of the specimen to jump suddenly from 10g to 30 or 40g. Since such a high level of acceleration is an unfair test, as well as a possibly destructive one to the specimen, all possible precautions must be taken to avoid this situation. A satisfactory method for decreasing the possibility of such an event is a resonant search, before the test, at low level (½g or 1g) and a notation of where the resonant frequencies occur.

Hardly any problems occur in vibration testing at single frequencies, such as at the resonance described in Procedure I of MIL-E-5272. The signal amplitude is simply increased until the desired level of acceleration is reached.

Vibration testing with alternator power supplies is much the same as using an amplifier and oscillator combination. However, the operator must remember that the rotary generators have a great deal of "moment of inertia," and thus at fairly rapid sweep rates, considerable lag exists between the time a frequency is called for and when it occurs. The operator must be extremely cautious in monitoring the specimen acceleration during any sweep test to prevent possible damage of the specimen during any high Q resonances that may be excited suddenly.

Multifrequency Vibration Testing

Multifrequency vibration testing can call for a uniform spectral density shake test between specified frequency units, or a shake test with a shaped spectral density function within prescribed limits. The units of spectral density are usually expressed in g^2/cps. The theory of random noise is beyond the scope of this article. This is a complex subject and requires a great deal of mathematics to prove the fundamental relationships describing the response of structures to random loading.

Once the function of spectral density versus frequency has been established, the rms g level has likewise been established. For example, if it is desired to run a test at

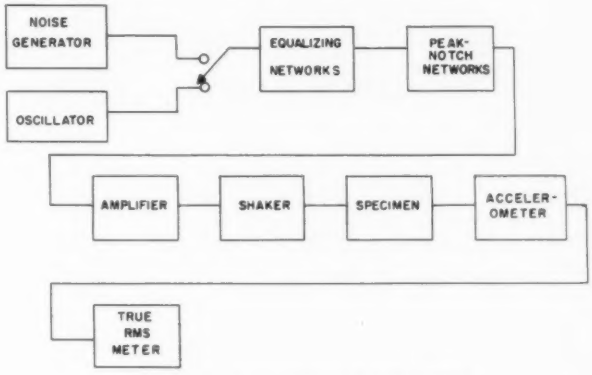

Figure 8. Arrangement of test equipment for a random noise vibration test.

a spectral density level of $0.2g^2/cps$ between 20 and 2,000 cps, the rms g level may be computed by Equation D.

$$R = \sqrt{\int_a^b g\ df}$$

where R = rms g level

a = lower freq. limit

b = upper freq. limit

g = spectral density, g^2/cps

$$R = \sqrt{\int_{20}^{2,000} 0.2df} = \sqrt{0.2f \Big|_{20}^{2,000}}$$

$$R = 19.9 \text{ rms g}$$

EQUATION D

Once the specimen has been mounted on the shaker, the process of *shaping* must be done. This process is to produce a uniform transmissibility function between the shaping network input and the shaker table output, that is, if a sine-wave oscillator is connected to the input of the system, when the oscillator frequency is varied at

(Continued on Page 25)

New Literature

News of literature of interest in the environmental field is welcomed by the editor. Send releases to the *Environmental Quarterly*, Rm. 524E, 30 Church St., New York 7, N. Y.

Applied Electrical Measurements, a 600 page book by Dr. Issac F. Kinnard of General Electric's Instrument Department, has just been published by John Wiley & Sons, New York City.

Dr. Kinnard presents the principles of electrical measurement devices and their application to electrical and non-electrical quantities. He covers the field in relationship to physics, electricity, light, heat, statics and kinetics, liquids and gases, and time.

GE engineers who contributed chapters are: F. E. Arnold, A. J. Corson, H. C. Dickinson, M. A. Princi, A. Hansen, Jr., E. E. Lynch, H. E. Trekell, R G. Jewell, J. R. Macintyre, N. P. Millar, A. G. Stimson, J. H. Wright, A. White, and C. F. Savage.

A "nuclear scorecard," with thumbnail profiles of various reactor types and how they compare or differ, has been prepared by Minneapolis-Honeywell's Industrial Division. The 8-page booklet was published in an effort to dissipate fog surrounding reactor terminology.

The booklet defines the basic reactor classifications and the specific reactor types. In familiar terms, it gives the name of a reactor, origin of the name, and the reactor's essential features.

Although originally intended for businessmen, the booklet has already stimulated scores of requests from perplexed engineers!

For copies of this booklet, circle 501 on Reader Service Card.

A new bulletin describing the company's line of humidity recording and controlling instruments, has been announced by The Bristol Company of Waterbury, Connecticut. The bulletin covers indicating, recording, and automatically controlling wet and dry bulb instruments, and direct reading psychrometers, and a full line of accessories: wet bulb fixtures, valves, and motor operators for louvers, ducts, etc. Also included are conversion tables of wet and dry bulb temperatures and psychrometric tables.

For a copy of this bulletin, circle 511 on Reader Service Card.

Opportunities in physics, electrical engineering, math, and psychology are listed in bulletin issued by R & D, M.I.T. Lincoln Lab., Dept. EQ, Box 24, Lexington, Mass.

High vacuum systems are discussed in booklet offered by Central Scientific Co., Chicago. **For a copy, circle 521 on Reader Service Card.**

The solar furnace as a tool for high-temperature is subject of booklet 56-F-7, ASME, Dept. EQ, 29 W. 39 St., N. Y. 18, N. Y. 50c

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Instrument directory for 1956-57. Neely Enterprises, N. Hollywood, Cal. **For a copy, circle 531 on Reader Service Card.**

FTC HEARS THE ENVIRONMENTAL EQUIPMENT INDUSTRY

At the invitation of the Federal Trade Commission, representatives of the environmental equipment industry assembled in New York City on October 19, 1956, to voice their opinions on the subject of proposed fair trade practices rules for that industry. Under the general supervision of Mr. William Dixon of the FTC, the group took up one by one the rules prepared as a proposal by the Environmental Equipment Institute, chiefly through the efforts of the Institute's counsel, Mr. S. David Leibowitt.

This conference is the first step in proceedings authorized by the FTC for establishing trade practice rules for the industry.

Although the establishment of a code of trade practice rules for the industry has been a project of the Environmental Equipment Institute since 1953, the FTC had made it plain in an announcement to the industry in September that any person or business in the industry could submit suggested rules for consideration at the conference.

The purpose of such a code is to eliminate and prevent unfair competition, unfair or deceptive acts or practices, and other trade abuses that are in violation of the laws administered by the FTC.

At the conclusion of the conference, Mr. Dixon pointed out that the next step would be for him to prepare a draft of proposed rules, based on the conference, for presentation to the Commissioners. Before any rules are finally approved by the Commission, he said, a draft of the rules will be made available to all who are interested or affected, including not only members of the industry but consumers and consumer organizations.

Mr. Dixon went on to say that the Commission will issue a formal public notice of a public hearing so that all concerned will have an opportunity to present their views, criticisms, and suggestions regarding the proposed rules.

The public hearing will probably be held in Chicago in April in connection with the annual meeting of the Environmental Equipment Institute.

ENVIRONMENTAL EQUIPMENT INSTITUTE HOLDS SEMI-ANNUAL MEETING

Seated, L. to R. Ted Augustyn, Vice Pres., American Research Corp.; S. D. Leibowitt, EEI Counsel; Jack Shamroth, Pres., American Research Corp.; D. E. Haskins, Vice Pres., and P. H. Brandt, Murphy & Miller, Inc.; Charles C. E. Harris, Pres., Harris Refrigeration; and J. R. Jacobson, Pres., Cincinnati Sub-Zero Products.
Standing, L. to R. Ray H. Mattingley, Editor, *Environmental Quarterly*; Charles E. Earl, Pres., EEI, and Pres., Alpha Electric Refrigeration Co.; E. S. Brown, Vice Pres., EEI, and Pres., Standard Cabinet Co.; R. S. Jamison, Asst. to the Pres., Cincinnati Sub-Zero Products; Saul Schiffman, Vice Pres., Tenney Engineering, Inc.; James Scibetta, Bowser Technical Refrigeration; and George D. Wilkinson, General Manager, EEI.

With Mr. Charles E. Earl presiding, the EEI held its 1956-57 semi-annual meeting in New York City on October 19, immediately after the Federal Trade Commission conference on trade practice rules for the environmental equipment industry. Mr. Earl opened the meeting by introducing Mr. D. E. Haskins and Mr. P. H. Brandt, representing the new member of the Institute, Murphy and Miller, Inc., of Chicago.

Mr. George D. Wilkinson, General Manager of the EEI, labeled the Federal Trade Commission conference an important milestone in the Institute's long-range program to stabilize the industry (story on page 22).

Mr. Earl reported that members of the Executive Committee had met with representatives of the Executive Committee of the Institute of Environmental Engineers and that the two groups had formed a Joint Council of the EEI and the IEE to work on projects of mutual interest: particularly the *Environmental Quarterly* and a *Handbook of the Environment*.

The Institute of Environmental Engineers had invited the EEI, Mr. Earl said, to help set up a manufacturer's exhibit at the Annual Meeting of the IEE and to assist in laying out the technical program. Members of the EEI heartily accepted this invitation.

The Annual Meeting of the EEI was set for Wednesday, April 24, at the La Salle Hotel in Chicago.

— CALENDAR —

JANUARY, 1957

5-7	Cryogenic Engr. Conf., Boulder, Col. Problems at temperatures below 150K. For information, contact P. L. Barrick, Nat'l Bur. of Stds., Cryogenic Engrg. Lab, Boulder, Col.
14-15	Third Nat'l Symposium on Reliability & Quality Control in Electronics, sponsored by IRE, AIEE, RETMA, and ASQC, Hotel Statler, Washington, D. C.

FEBRUARY, 1957

4-8	Am. Soc. for Testing Materials, committee week nat'l meeting at Ben. Franklin Hotel, Philadelphia.
25-Mar. 1	Internat'l Heating & Air-Conditioning Exposition, sponsored by Am. Soc. of Htg. and Air-Condtg. Engrs., Chicago.

MARCH, 1957

7	N. Y. Chap., Inst. of Environmental Engineers. Guest speaker: Lt. Col. W. C. Marcus, USAF, on *Trends of Aircraft in Relation to Environment Testing*. Host: Stratos Div., Fairchild Engine and Airplane Corp.
7-9	Optical Soc. of Am., spring meeting, New York City.
10-13	Am. Inst. of Chem. Engineers, Greenbrier Hotel, White Sulphur Springs, Va.
11-15	Nuclear Congress' Internat'l Atomic Exposition, Convention Hall, Philadelphia.
8-21	Inst. of Radio Engineers, Nat'l Convention, Coliseum, New York City.

APRIL, 1957

7-12	Am. Chem. Soc., Nat'l Meeting, Miami.
8-10	Am. Soc. of Mech. Engineers, Dinkler-Tutwiler, Birmingham, Ala.
11-13	Southwestern IRE Conf. & Electronics Show, Shamrock Hotel, Houston, Texas.
22-24	Instrument & Regulators Conf, ASME, Northwestern U, Chicago.
24	Environmental Equipment Institute, Annual Meeting, La Salle Hotel, Chicago. Federal Trade Commission Conference, trade practice rules for environmental equipment industry, Chicago.
25-26	Institute of Environmental Engineers, Annual Technical Meeting, La Salle Hotel, Chicago.

IEE LAUNCHES MEMBERSHIP DRIVE

(Continued from Page 13)

granted membership in the IEE upon proper request.

Two persons may be designated to act as Representatives.

Representatives are accorded the privileges of Members, except the right to vote, sign petitions, and hold office. When an individual ceases, for any reason, to be a Representative, he may become a Member by payment of one year's dues for that classification.

A Government Agency Member pays no dues.

To apply for Membership, the commanding or executive officier must address a letter-request to Dr. George D. Wilkinson, General Manager, IEE, Room 524E, 30 Church Street, New York 7, New York. Designated Representatives are required to fill out a Member application form for the records of the IEE.

Company

Any private Company or firm not commercially engaged in the design and/or manufacture of and/or sale of environmental test equipment, and having an interest in environmental science, simulation, or testing, is eligible to become a Company Member.

The Company Member may be represented by a maximum of 5 employees at all IEE meetings at the same cost for each as for a Member. Representatives may be designated or changed at any time, but the Company should notify the General Manager of changes.

A Company Member is entitled to 3 copies of the *Environmental Quarterly* and the "Proceedings of the Annual Meeting." A Company Member has no vote, holds no office, and has no right to sign petitions.

Dues are $100.00 per year. Application blanks will be supplied upon request.

Local Chapters

The formation of Local Chapters is one of the early goals of the IEE.

Any Member or Government Agency representative may undertake to establish a Local Chapter in his area.

Requirements for Local Chapter qualification are explained fully in the by-laws of the Institute, which are sent automatically to each new member.

To help in the organization of Local Chapters, the General Manager provides a kit of materials, including a list of qualified speakers, to any Member desiring to initiate a Local Chapter.

At present, Local Chapters are being formed in New York City, Chicago, Baltimore, and Ottawa, Canada.

Each local chapter elects one Director to serve on the Executive Committee of the Institute.

Annual Meeting

The IEE sponsors a major technical meeting each year for the purpose of presenting a wide range of up-to-the-minute authoritative information and the most advanced thinking in the field of Environmental Engineering.

The 1957 Annual Meeting is scheduled for April 25 and 26 at the La Salle Hotel in Chicago. A distinguished group of speakers from Industry, Government, and the Universities of the Nation are being engaged for the coming symposium.

Publications

Proceedings of the Annual Technical Meeting

The "Proceedings" include all papers presented at the Annual Meeting plus the question-and-answer periods following each paper and panel discussion.

A copy of the "Proceedings" is sent at no extra cost to each person who attends the meeting and to each Member of the IEE, whether he attends the meeting or not. Additional copies are offered to the public at a price established each year.

Environmental Quarterly

The *Quarterly* is the official organ of the IEE, published jointly with the Environmental Equipment Institute. It contains articles of timely importance and interest presented in popular rather than in heavy technical style. It also serves as the newsletter of the Institute with reports of Local Chapter activities, notices of meetings, membership lists, and personal notes. It is a medium for the interchange of ideas through the publication of letters from members and others.

Handbook of the Environment

The *Handbook* is to be a compilation of all available data on the characteristics of the physical environment, methods of simulating them, and methods of testing under simulated conditions.

Although it will include some material available in other works, much of it will be new. It will be the first single source book for test engineers, designers, manufacturers, and research students in the field of Environment. It is to be published in loose-leaf form – punched, dated, and indexed for easy replacement of obsolete material.

QUESTIONS & ANSWERS

(Continued from Inside Front Cover)

Can You Answer This One?

Dear Sir:

In the design of a high temperature walk-in chamber, a problem has been encountered with bearing lubrication. The design of the chamber is such as to require mounting the bearings inside the chamber where the air temperature is between +500°F and −100°F with an altitude of 100,000 feet.

The question is — does anyone know of a lubricant which will retain its lubricating qualities to +550°F, still have reasonably low torque at −100°F, and be unaffected by the combination of high altitude and high temperature?

H. C. Jones, Sr. Engr.
Environmental Test Section
Air Arm Div.
Westinghouse Electric Corp.

NOTE: Please address replies to this month's question to the attention of the editor.

VIBRATION TESTING FOR THE NEOPHYTE

(Continued from Page 21)

constant voltage output, constant acceleration will result in the shaker table motion. The need for this process results from resonances in the specimen that feed back and affect the shaker table motion. A block diagram of a typical random noise vibration system is shown in Figure 8.

Shaping Networks

Shaping networks, usually referred to as peak-notch networks, are available commercially. The networks resemble the reciprocal of mechanical resonances and anti-resonances. There is provision for control over frequency and Q of the peak-notch networks.

One procedure that may be used to shape the transmissibility function to the desired uniform transmissibility is a commercially available device that contains a sweep oscilloscope, which produces a signal that varies in frequency at a uniform rate between specified limits at constant voltage. The device also contains a cathode ray tube and the appropriate circuits, so that a picture of acceleration-versus-frequency may be presented.

With this picture in front of the operator, adjustment of the peak-notch network can be made until the function of acceleration-versus-frequency is horizontal to the frequency axis up to 2,000 cps, and then drops rapidly to zero.

The process of adjusting these networks is not easy, for very often the operator will be trying to adjust five or six peak-notch units simultaneously. After a while, remembering which knobs affects which bump on the transmissibility curve, and how much the adjustment of any unit affects the adjustment of any other unit becomes rather difficult. Often an operator will become so confused he would save time by starting all over again.

Since, in the method discussed here, the specimen is being subjected to vibration continuously during adjustment of the peak-notch network, making the actual adjustment this way would be highly undesirable. Shaker manufacturers have devised methods of doing the same thing by performing only a single sweep at low level. This avoids the possibility of damage to the specimen that might be caused by sustained unmeasured vibration during peak-notch network adjustment.

The method used is too lengthy for discussion here. The shaker manufacturer can advise in this matter when random noise tests must be made.

Once the shaping is done, the system is ready for a uniform spectral density shake test. All that is necessary is to replace the sweep oscillator with a random noise generator and terminate the accelerometer used in making the peak-notch adjustments in an rms meter. It would be a good idea to monitor the accelerometer output on an oscilloscope to check for overdriving of the system. To obtain the desired level of 20 rms g, as in our example, the gain of the system is simply increased until the rms meter indicates that the proper level has been reached.

END

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$1.00 per line, minimum charge $3.00. $2.00 for use of Box No. instead of name and address. Forms close January 20 for First Quarter 1957 issue. Address all correspondence to Classified Adv. Dept., *Environmental Quarterly*, Rm. 524E, 30 Church St., New York 7, N.Y.

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LT. COL. MARCUS TO SPEAK AT IEE CHAPTER MEETING

Lt. Col. Woodrow C. Marcus, Wright Air Development Center, will be the principal speaker at the March 7, 1956, meeting of the New York Metropolitan Chapter of the Institute of Environmental Engineers. His subject will be "Future Trends of Aircraft as Applied to Environmental Testing."

Lt. Col. Marcus is Chief, Design Criteria Div., Directorate of Engineering, Deputy Commander for Research and Development, at WADC.

Host for the meeting will be Stratos Div., Fairchild Engine and Airplane Corp.

DIRECTORY OF IEE MEMBERSHIP

(Continued from Page 15)

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A. KUZMICKEY, Convair-Div. of Gen. Dynamics Corp., Grants Lane, Fort Worth
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SNOW, ICE, & PERMAFROST RESEARCH EST., Corps of Engineers, Wilmette, Ill., Robert W. Gerdel
SURVEILLANCE LAB., Army Chemical Corps, Camp Detrick, Md., George Mader, R. M. Whitmore

ASESA

Qualification-Testing Program

The Armed Services Electro-Standards Agency (ASESA) is expanding its Qualification-Testing Program because of a growing need for qualified parts suppliers.

To supplement Government testing labs ASESA recently set up a program of qualification-testing of electronic and electric parts in commercial testing labs and in the plants of parts manufacturers. Because of the effectiveness of this program, ASESA now plans to permit qualification-testing in the plants of electronic-equipment manufacturers.

Manufacturers who believe their facilities to be adequate for such testing and who want more information are encouraged to contact the Director, ASESA, Fort Monmouth, N. J.

Testing labs and parts manufacturers unfamiliar with this program are also encouraged to contact ASESA.

IEE TO HOLD ANNUAL MEETING

According to Mr. Henry F. Sander, President, the IEE will hold its first Annual Technical Meeting on Thursday and Friday, April 25 and 26, 1957, at the La Salle Hotel in Chicago. Although this is the first technical meeting for the IEE, it will be the third annual meeting sponsored by this group. The IEE, before its incorporation in July of this year, was the Science Section of the Environmental Equipment Institute. As the Science Section, this group sponsored national technical meetings on environmental simulation and testing in April of both 1955 and 1956.

Mr. Sander has stated that the program for the 1957 meeting is developing nicely, but that he is still interested in hearing from anyone who would like to present a paper on some phase of environmental testing. Mr. Sander's address is: Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

Mr. Sander has announced the appointment of Mr. Stephen Danko, Motorola Radio Co., Chicago, as Program Chairman. Also working on the Committee are Mr. Robert Stallard, General Electric Co., Utica, N. Y., and Mr. Harold C. Jones, Westinghouse Air Arm Division, Baltimore, Md.

The complete program for the Annual Meeting will be published in the next issue of the Quarterly.

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IEE LOCAL CHAPTER NEWS

CHICAGO—On September 28, the proposed Local Chapter for the Chicago Metropolitan Area met to hear Mr. Harold C. Jones, of Westinghouse, discuss a "Philosophy of Environmental Testing." Mr. Jones is Senior Engineer, Environmental Test Section, Westinghouse Air Arm Division, and also is Vice President in Charge of Fiscal Affairs of the IEE.

"To formulate an environmental test intelligently," Mr. Jones said, "the engineer must first acquire detailed knowledge of the vehicle in which the equipment is to be mounted. Then, based on the environment within the vehicle, the engineer should devise a detailed specification for testing the equipment to insure its operation under this environment. Sound engineering judgment is required." Mr. Jones continued, "to provide tests that are meaningful and non-destructive. It is not sound testing to use a destructive test if a test to lower level plus sound engineering judgment will reveal what the results of the destructive tests would have been. In this requirement for judgment lies the factor that has made Environmental Engineering a profession, for environmental testing cannot be reduced to a mere set of routine operations."

CHICAGO—The second meeting of the proposed Local Chapter for the Chicago Metropolitan Area on October 24 was attended by thirty-five people. The speaker for the occasion was Mr. R. H. Jacobson, of the Armour Research Foundation, speaking on "Effects of Shock and Vibration Environments on Electronic Components." Mr. Jacobson covered the vibration, shock, and acoustic test results on five components: tubes, relays, transformers, capacitors, and potentiometers.

Mr. Jacobson described a small, high-intensity sound chamber designed and built by the Armour Research Foundation. The audience was keenly interested in this chamber because of its apparent low cost.

NEW YORK CITY—At a dinner meeting of the proposed New York Metropolitan Chapter of the IEE on October 25, guest speakers were Mr. A. W. Orlacchio of the Gulton Industries, Inc., and Mr. D. J. Shergalis of the Grumman Aircraft Engineering Corp.

Mr. Orlacchio's topic, "New Environmental Trends in Vibration Instrumentation," centered about the subject of transducer design. Mr. Orlacchio explained the construction of the two basic transducer designs used to obtain wide frequency response—the compression type and the bending action type. Such transducers make use of one or more piezoelectric disks. Bending action transducers have also been made of titanium, which has a natural resonant frequency of 60 kilocycles.

The bending action design is preferred, primarily because of the possibility of preventing the external acoustic pressures from producing voltage output.

With regard to problems encountered in the design of high temperature transducers, Mr. Orlacchio discussed thermal protective devices, high temperature materials and bonding devices, and the factor of rapidly increasing electrical conductivity with temperature rise.

Mr. Orlacchio concluded his talk with a discussion of techniques used in the calibration of transducers. Three approaches have been used to obtain high frequency calibrations: (1) use of a small electromagnetic vibrator optically calibrated; (2) use of the reciprocity method, which requires two accelerometers and a known mass; (3) use of piezoelectric vibrator to provide the vibrations and an interferometer system to measure displacements accurately.

Mr. Orlacchio said he would send a copy of his talk to anyone who writes him for one at:

Gulton Industries, Inc., Metuchen, N. J.

The second speaker, Mr. Shergalis, discussed the "Practical Aspects of Vibration Instrumentation." Mr. Shergalis is primarily concerned professionally with obtaining vibration information during actual flight. Because the cost involved in equipping an aircraft with the necessary recording instrumentation is extremely high, he said the problem of obtaining sufficient data is one of economics. Therefore, only the data considered most vital is explored. Both because of the high cost and because it might be impossible to duplicate an actual flight, the choice of instrumentation is extremely critical if reliable results are to be obtained. At present, tape recordings appear to be the best means of recording vibration information, according to Mr. Shergalis. Accuracy of the recording with regard to the output of the transducers is plus or minus 10 percent, he said.

NEW YORK CITY—On October 25 the temporary Steering Committee for the proposed New York Metropolitan Chapter of the IEE met to proceed with the actual organization of the Local Chapter. Those attending this meeting were: Mr. Bernard Friedman, Chief Engineer, Tenney Engineering, Inc.; Mr. Ralph Ferry, Laboratory Supervisor, Allied Control Corp.; Mr. Lawson Exley, Test Engineer, Aeroflex Research Co., Mr. John Cammarata, Head, Environmental Dept., Arma Div., American Bosch Arma Corp., Mr. Roger Amorosi, President, Parameters, Inc.; and Mr. Albert Tramposch, Chief Test Engineer, Parameters, Inc.

A nominating committee was chosen, consisting of Mr. Exley, Chairman, Mr. Tramposch, Mr. Frank Hallstein, Project Engineer, of Dayton T. Brown, Inc., and Mr. Amorosi. This committee then selected the following slate to be presented at the next meeting of the proposed Local Chapter.

(Continued)

NEW PRODUCTS

News of product developments are welcomed by the editor. Send releases to the *Environmental Quarterly*, Room 524E, 30 Church St., New York 7, N. Y.

A new low-temperature chilling machine with a 4 cubic foot chamber has just been developed by Cincinnati Sub-Zero Products, Cincinnati, Ohio, manufacturers of industrial chilling equipment.

The new unit is designed for laboratory testing in regard to quality control and product development uses. It has a net thermal capacity of approximately 600 BTU/hr. at −120° F, with a temperature selection from +80° F to −120° F, and full-range pull down in 45 minutes. By the addition of strip heaters, the temperature range can be extended to +200° F.

For more information, circle 551 on Reader Service Card.

New pressure switches designed for aircraft use by The Bristol Company of Waterbury, Conn., are devices for switching electrical circuits in response to pressure changes in gases, liquids, and the atmosphere. They will perform in any position, and are designed for the environmental requirements of the appropriate MIL specifications.

For more information, circle 561 on Reader Service Card.

For making transient vibration measurements over a wide frequency range, Massa Laboratories, Inc., Hingham, Mass., markets standard Accelerometer Models M-142B, M-191, and M-198.

The company claims that high order harmonic components of vibrations, will be revealed with this equipment. Another use is in making vibration measurements for noise reduction.

For more information, circle 571 on Reader Service Card.

A dynamic shock testing device, only 26 in. high and 3 in. in diameter, yet producing a 12,000-pound thrust, is being marketed by Consolidated Electrodynamics Corp. under license with Convair.

It is designed for shock testing of components for jet engines, aircraft, missiles and rockets.

The Hyge unit consists basically of a cylinder enclosed piston that is subjected to differential pressures on its two faces. There are only two moving parts—piston and a floating seal—with no complicated controls.

For more information, circle 581 on Reader Service Card.

To test the resistance to surface abrasion of materials under cold, wet, and dry conditions, Taber Instrument Corp., North Tonawanda, N. Y. offers the Model 174 abraser.

The instrument is used to test sheer silks, textiles, metals, leather, rubber, and linoleum for the automotive, aircraft, chemical, paint, plastic, and coatings industries.

For more information, circle 591 on Reader Service Card.

IEE LOCAL CHAPTER NEWS

(Continued)

Chairman—Mr. J. C. Ward, Head, Environmental Test Section, General Precision Labs., Inc.
Vice Chairman—Mr. Cammarata.
Secretary-Treasurer—Mr. Ferry.
Director (to represent the Local Chapter on the national Executive Committee)—Mr. Friedman.
Board of Directors of the Local Chapter—Mr. G. Chernowitz, Engineering Dept., American Power Jet Co.; Mr. Friedman; Mr. William Camp, Project Engineer, Heinemann Electric Co.; Mr. Exley; Mr. Hallstein, Mr. Norman Meyers, Project Engineer, Stratos Div., Fairchild Engine and Airplane Corp.; Mr. Tramposch, and Mr. Amorosi.
Committee Chairmen: Nominating, Mr. Exley; Technical, Mr. Meyers; Membership, Mr. Tramposch; Bylaws, Mr. Amorosi; Program, Mr. Friedman.

NEW YORK CITY—Dr. John T. Muller, of N. J. Dynamic Testing Laboratory spoke on "Transients in Mechanical Systems (Shock Motions)" before a heavily attended dinner meeting of the proposed New York Metropolitan Chapter of the IEE on Thursday, December 6, 1956.

Following Dr. Muller's speech, the meeting elected the slate of officers presented by the nominating committee chairman, Mr. Lawson Exley. These persons are listed in the preceding story.

In addition to being a lecturer in the Graduate School at Stevens Institute, Dr. Muller is a consultant on shock and vibration problems for the Sperry Rand Corp., Sperry Gyroscope Division, General Dynamics Corp., and Convair San Diego Division.

Some of the sub-topics of Dr. Muller's talk were:

Definition of a shock or transient.
Its relation to solid systems.
The effect on dynamic systems.
Evaluating test procedures and man hours required to test to submitted specifications.
Simulating equipment.
Value of transient testing.

Dr. Muller illustrated his lecture with high-speed motion pictures and with slides made at Bell Telephone Laboratories and at Sperry Gyroscope.

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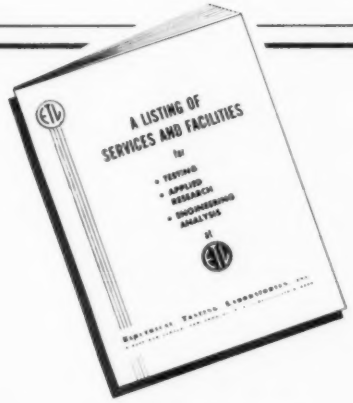

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